Loop Optimizer Suite

Product Guide

3BSE 016 144R201

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Chapter 1 Overview

Loop Optimizer Suite is the ultimate tool for creating and maintaining high quality plant production systems. The easy-to-use handling, powerful integrated multi-purpose tuning features and automatic Plant Loop Auditing supplies all features and functionality the most demanding user needs.

One of the unique features in the multi-purpose tuning capabilities is the possibility to supply closed loop re-tuning during on-going plant production. Via the integrated Plant Loop Auditing enhancements, plant production can be held at peak quality levels under longer periods.

Supported Plant loop structures range from conventional feedback to complex multi-variable, MIMO, solutions. Any Plant Loop structure can be used for simulation or On-Line loop tuning.

Loop Optimizer Suite combines the professional tuning capabilities with the outmost powerful features for plant QCS supervision and documentation.

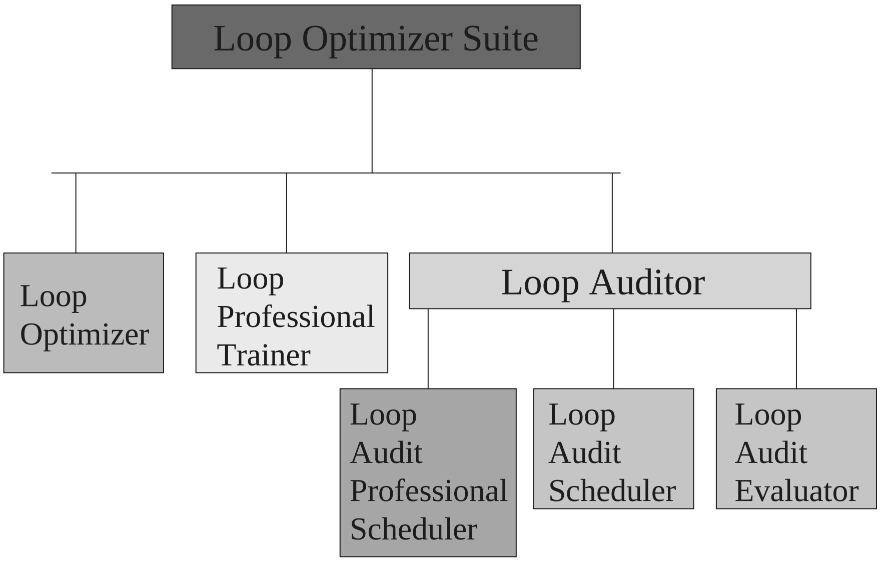


Figure 1-1. The Loop Optimizer Suite Structure

1.1 Feature and Benefits

The Loop Optimizer Suite consists of three main program modules. The three modules are built up of five different program parts.

Loop Auditor

The Loop Auditor contains the scheduling and reporting functions which supplies the Plant Auditing function. The Auditor uses a combination of advanced signal analysis, knowledge-based fuzzy logic technology and automatic evaluation of loop performance.

The Loop Audit Scheduler handles automatic scheduling of plant auditing session. Each auditing session is executed by the Loop Performance Assessment, LPA, Batch feature in the Loop Optimizer program part. The scheduling interval is user specified. The Loop Audit Evaluator is activated by the Scheduler in accordance with the user selected interval. Each set of Quality Indexes calculated during an LPA Batch activity evaluates the plant loop from different perspectives to optimize perception of changing plant conditions. Via the Loop Quality Indexes, production will be notified about possible problems long before it starts to influence the production quality, that is, early warnings!

Loop Optimizer

The Loop Optimizer is an automatic system which determines tuning parameters for optimum loop performance. The module handles multiple loop structures including feedback, feedforward, cascade and interactive or cross coupled loops. In addition, there is a Loop Historian that stores all registered loop activities.

The Loop Optimizer program part runs as the executive batch engine during calculation of Quality Indexes at an LPA Batch activity driven by the Loop Audit Scheduler. Besides this, the Loop Optimizer is built up of six tightly integrated modules which normally supplies fully automatic session for:

- On-line plant excitation, three different methodologies
- Model Identification, handled via the Identification Governor
- Controller Design, handled via the Controller Design Governor
- Plant Loop Simulation, all four loop structures
- Statistical Process Control
- Loop Historian

Loop Professional Trainer

The Loop Professional Trainer is a stand-alone professional dynamic loop simulator. It gives the user a possibility to reach a professional level in loop tuning and understanding, without having to take into consideration if plant production is disturbed. Via the open model concept, site specific models identified and tuned by the Loop Optimizer can be easily integrated into the Loop Professional Trainer. Thereby site specific loop dynamics can be used during the training. Each such description can be displayed together with an application specific picture that makes the whole training very realistic and understandable.The Loop Professional Trainer comes with five pre-defined plant loop models that range from loops with fairly simple dynamics until loops with higher degree of complexity. On top of this, the user can easily add further site problems such as hysteresis, noise and disturbances.

Chapter 2 Functional Description

2.1 Loop Auditor

The Loop Auditor in Loop Optimizer Suite is divided into three program parts. The Loop Audit Scheduler handles automatic scheduling of plant auditing session. Each auditing session is executed by the Loop Performance Assessment, LPA, Batch feature in the Loop Optimizer. In each LPA Batch session a maximum of 100 loops can be included for sequential auditing. The scheduling interval is user specified. Other means of activating a full LPA Batch activity would be from a web-browser, if remote analysis is required! The Loop Audit Evaluator is activated by the Scheduler according to the user selected interval. Between the automatically generated Reports the user can on demand activate the supervision of all Loop Quality Indexes.

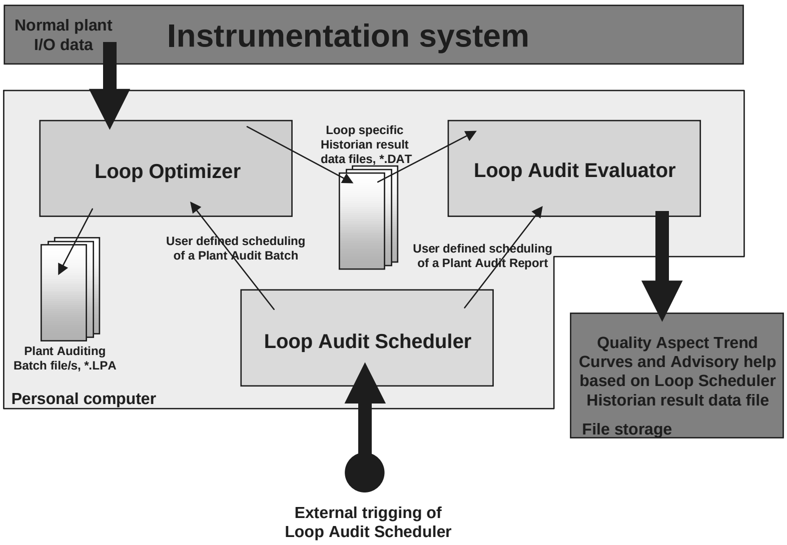

Normal plant I/O data
Instrumentation system
Loop Optimizer
Loop specific Historian result data files, *.DAT
Loop Audit Evaluator
User defined scheduling of a Plant Audit Batch
User defined scheduling of a Plant Audit Report
Plant Auditing Batch file/s, *.LPA
Loop Audit Scheduler
Quality Aspect Trend Curves and Advisory help based on Loop Scheduler Historian result data file
File storage
Personal computer
External trigging of Loop Audit Scheduler

Figure 2-1. Plant Loop Auditing

Each LPA session can supply up to 20 different Quality Indexes for each activated loop. Each set of Quality Indexes evaluates the plant loop from different perspectives to optimize perception of changing plant conditions like hysteresis/friction in control object (valve, pump, fan, etc.), loop dynamics (clogging of heat surfaces, loss of measurement device sensitivity, etc.), loop disturbance characteristics, etc. Via the Loop Quality Indexes production will be notified about possible problems long before it starts to influence the production quality, that is, early warnings!

A normal scheduling interval to use is three times a day. The length of the supervision time for a loop should from statistical point of view cover approximately 20-30 times the loop dynamics. During the time of the loop dynamics 12-20 values should be sampled making the total number of data points used for each investigation to be appr. 600 values.

A Plant Audit Report contain two types of information for each loop that has been analyzed within the LPA batch activity. The first part displays the trend curves of all Quality Index variables. The last 100 sets of Quality Index variables are always un-compressed while the others are compressed depending on the amount of available data in the Loop Scheduler Historian.

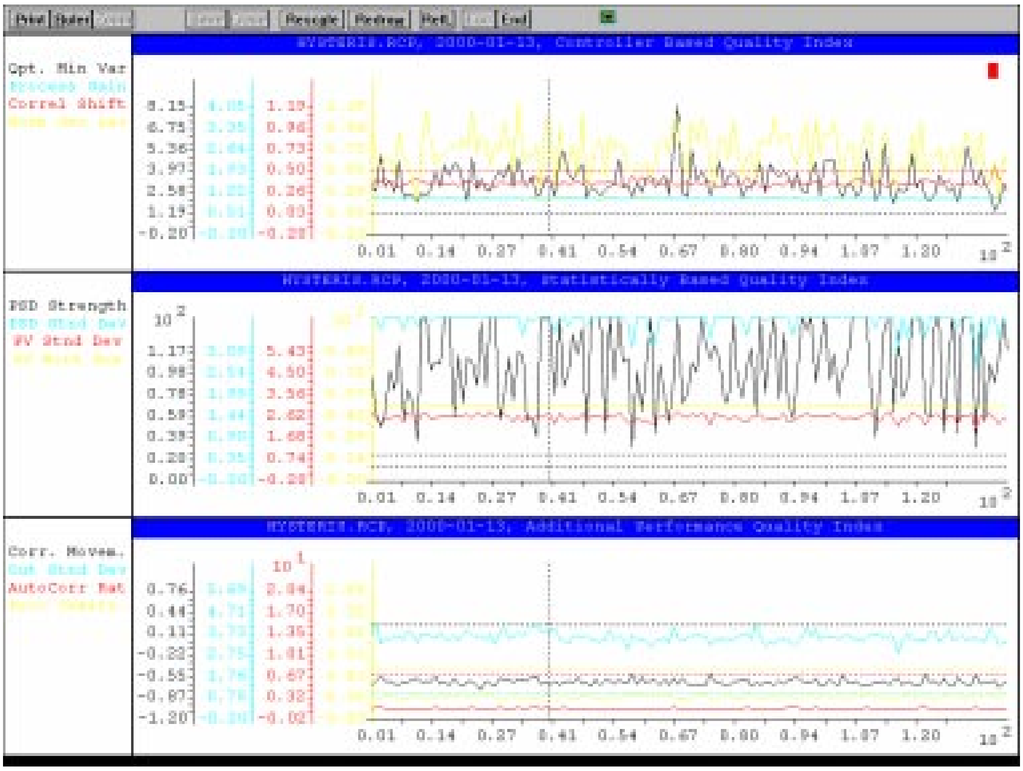
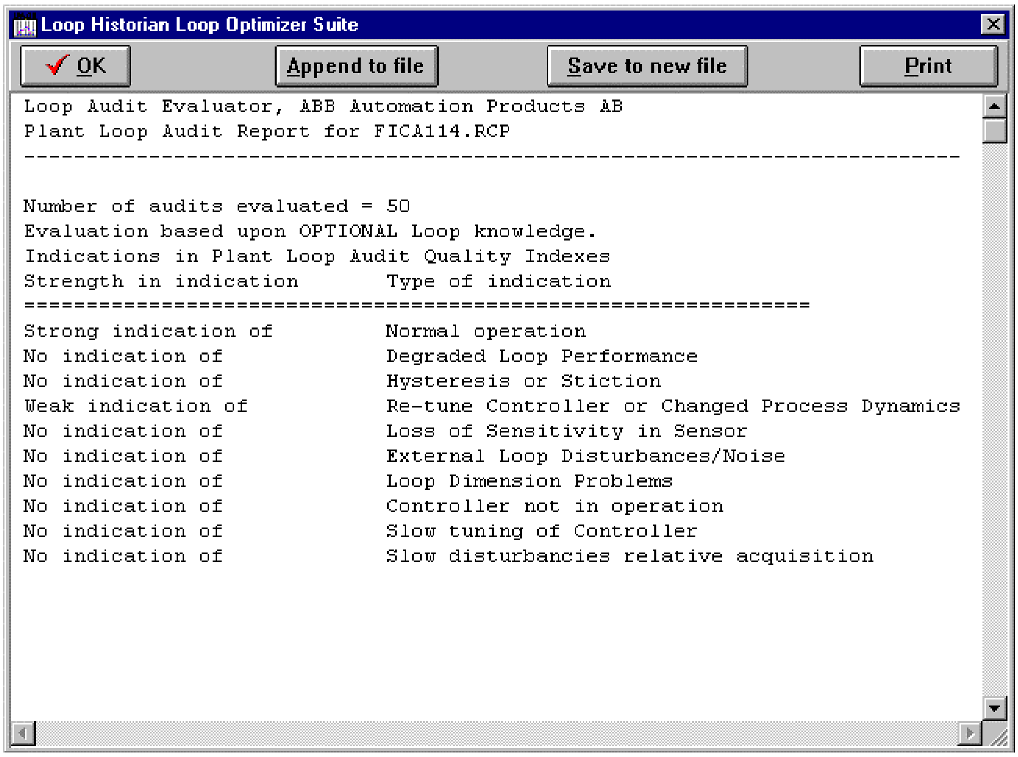


Figure 2-2. Trend curves of Quality Indexes

The other part of the report is a textual part were it is explained what the Quality Indexes has indicated, that is, a problem report as indicated below. The loop report is divided in three evaluation time zones. One that covers the last 100 sets of LPA activities, i.e. one month, and two which covers the last and the previous week. The horizontal dotted lines represent the reference levels for each individual Quality Index variable.



```
Loop Audit Evaluator, ABB Automation Products AB
Plant Loop Audit Report for FICA114.RCP
---------------------------------------------------------------------------

Number of audits evaluated = 50
Evaluation based upon OPTIONAL Loop knowledge.
Indications in Plant Loop Audit Quality Indexes
Strength in indication       Type of indication
===============================================================
Strong indication of         Normal operation
No indication of             Degraded Loop Performance
No indication of             Hysteresis or Stiction
Weak indication of           Re-tune Controller or Changed Process Dynamics
No indication of             Loss of Sensitivity in Sensor
No indication of             External Loop Disturbances/Noise
No indication of             Loop Dimension Problems
No indication of             Controller not in operation
No indication of             Slow tuning of Controller
No indication of             Slow disturbancies relative acquisition
```

Figure 2-3. Loop Evaluation Report

If the Loop Audit Professional Scheduler is used, data will be acquired from an external data acquisition package like “Enterprise Historian” from ABB Automation Products or “ARGUS” from ABB Service. The Loop Audit Professional Scheduler program part is not yet released.

2.2 Loop Optimizer

2.2.1 On-Line Plant Loop Tuning

Via the built-in powerful features, each tuning session can be executed depending on the plant production allowance. Fully automatic tuning sessions, push-button alike, can be done in three ways. One uses the PRBS excitation technique, another uses an extended Relay and Rule Based methodology and the last uses an Extended Functionality Test Pattern. Each of the available methodologies can be used but PRBS is recommended as the basic loop excitation technology

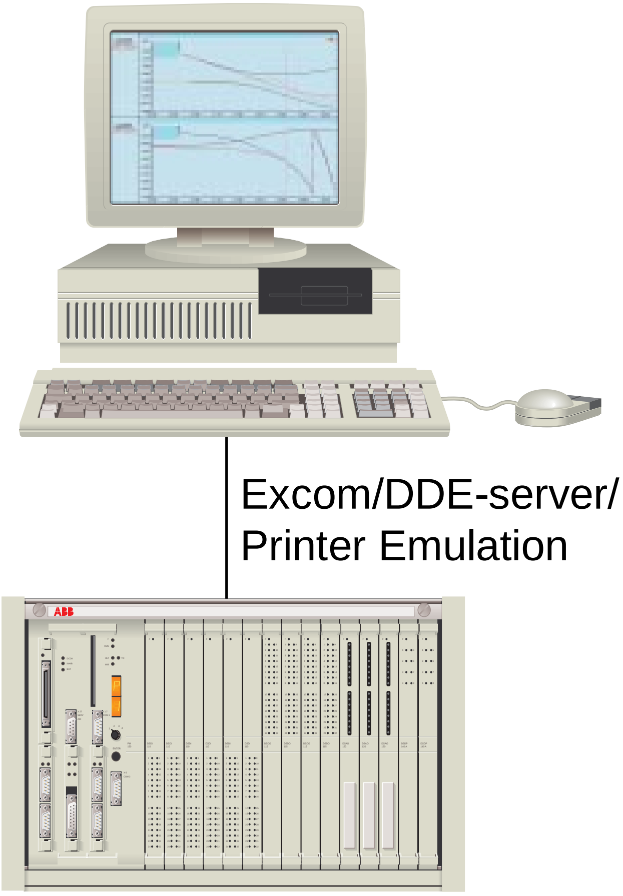


Figure 2-4. On-Line Plant Loop Tuning

Full controller mode switching capability is included. If mode switching is not accepted from plant production, plant loop tuning can also be done during on-going plant production with the controller running in AUTO - mode. This very unique feature for Loop Optimizer Suite makes it the ultimate On-Line tuning tool.

The On-Line Plant Loop Tuning part not only supports tuning of the conventional Feedback loop structure but also handles tuning of all the other available loop structures.

2.2.2 Plant Simulation

The Plant Loop Simulation part of Loop Optimizer Suite supplies the full scope of extended simulation features. Closed loop dynamics, open loop dynamics, Bode and Root locus diagrams are presented in easy to understand graphic forms fully using the embedded features of the Intelligent Graphics Interface, IGI.

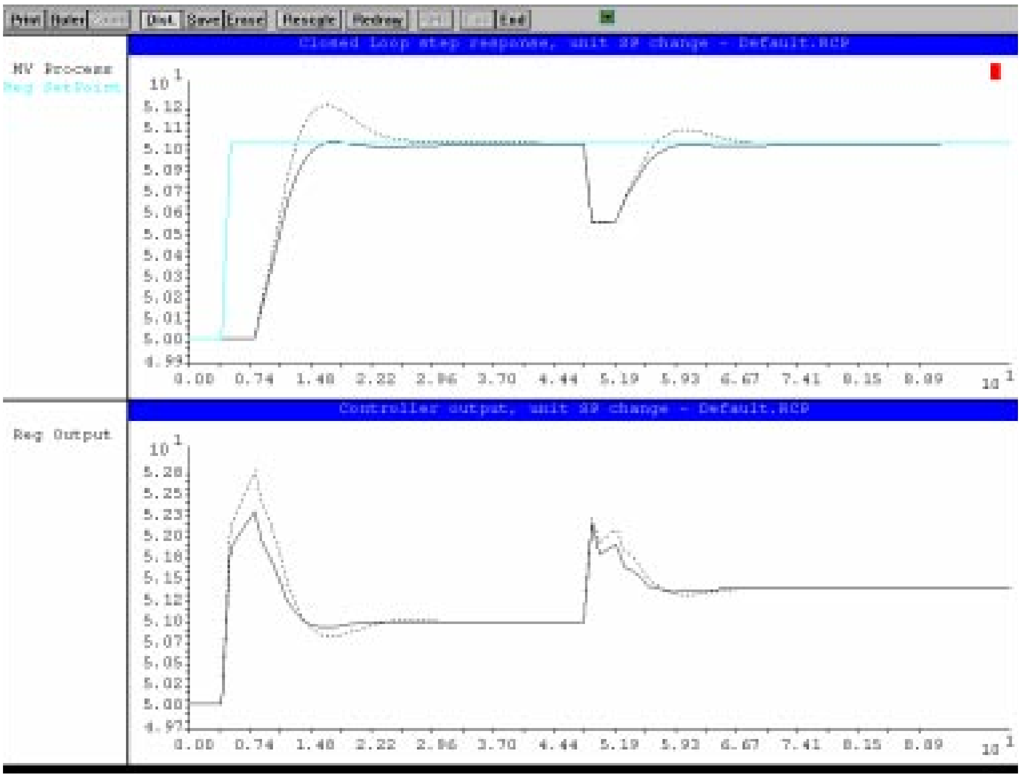


Figure 2-5. Plant Loop Simulation

A Plant Loop Simulation can represent not only the conventional feedback loop structure but supplies also full support for feedforward, cascade and multi-variable, 2x2 MIMO, loop structures.

The broad spectrum of supported plant loop representations is a unique feature for Loop Optimizer Suite and further strengthen its outstanding position as a market leading plant simulation tool.

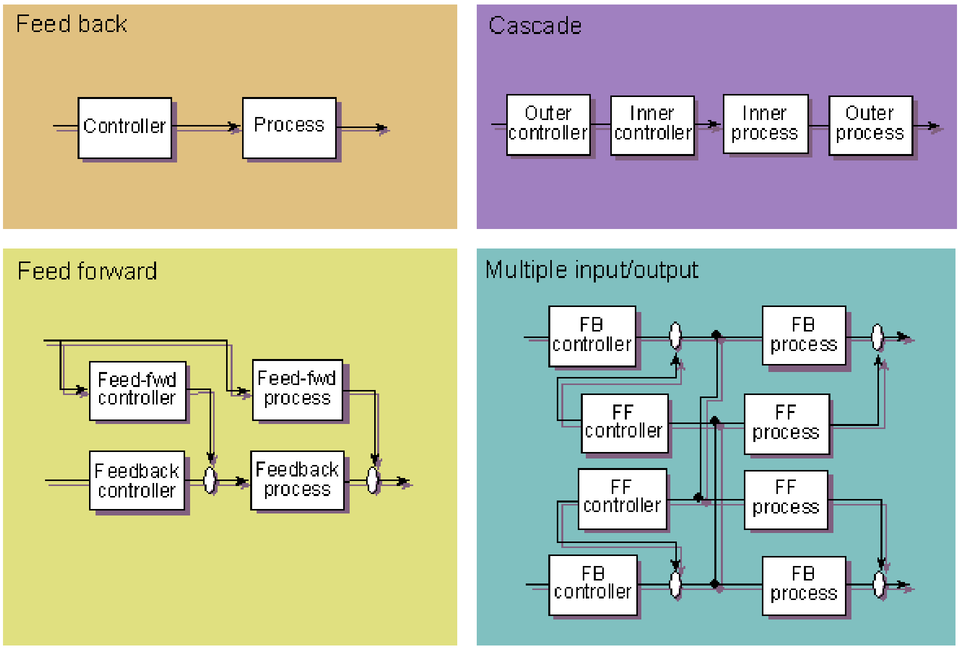


Figure 2-6. Supported Plant Loop structures

As a result of load and performance requirements, the minimum variance controller, Novatune, is supported in the Feedback loop structure only.

2.2.3 Plant Loop Identification

The Plant Loop Identification part in Loop Optimizer supplies an outstanding set of fully integrated powerful utilities, handled by the Supervisory Identification Governor, SIG. Thereby the plant loop dynamics can be identified directly from the raw data, without any user assistance. The Supervisory Identification Governor is an heuristic database that governs the model building, identification of loop dynamics, as if done by a leading authority in system identification.

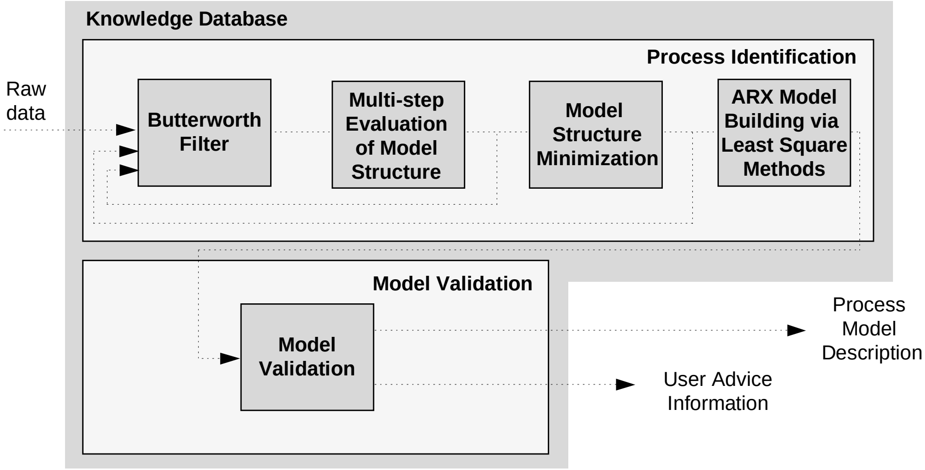

Knowledge Database
Process Identification
Raw data
Butterworth Filter
Multi-step Evaluation of Model Structure
Model Structure Minimization
ARX Model Building via Least Square Methods
Model Validation
Model Validation
Process Model Description
User Advice Information

Figure 2-7. Plant Loop Identification

Open or closed loop system identification is handled automatically by the SIG. If knowledge is available, the SIG can be given further directions, limitations or wishes how the identification should be done. In this manner each an every plant loop situation can be covered. All aspects in model building is automatically covered by the SIG in combination with an advisory assistance service.

An initial process model validation is done via the heuristic database. The user should thereafter do a graphical validation. The graphical validation is illustrated in Figure 2-8. Two trend curves present the built process model from two different perspectives. The top curve shows how it describes acquired raw data. The lower window displays the data filtered so that the frequency range of interest is further highlighted, that is, the controller band-width. The lower window is the top priority window for evaluation of built process models. Without a graphical validation like in Figure 2-8, a process model should never be accepted. Loop Optimizer Suite is again unique in its possibility to make such decisions easy and understandable for the engineer.

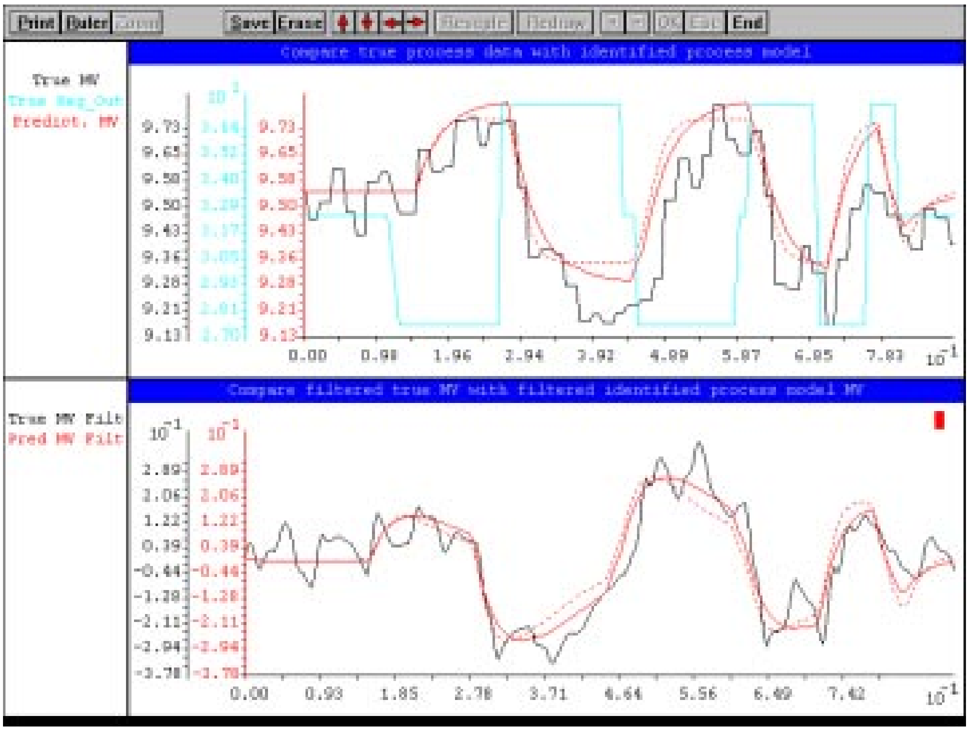


Figure 2-8. Validation of identified process model

2.2.4 Controller Design

The Controller Design part of Loop Optimizer Suite supplies support for controller design of different PI- and PID controllers. The special type of controllers used for extended feedforward control, Gain-Delay structure, are also handled automatically. The minimum variance type of controller is also covered by the Controller Design part. Every design is automatically driven by the Supervisory Tuning Governor, STG, based on the controller in the active worksheet; recipe.

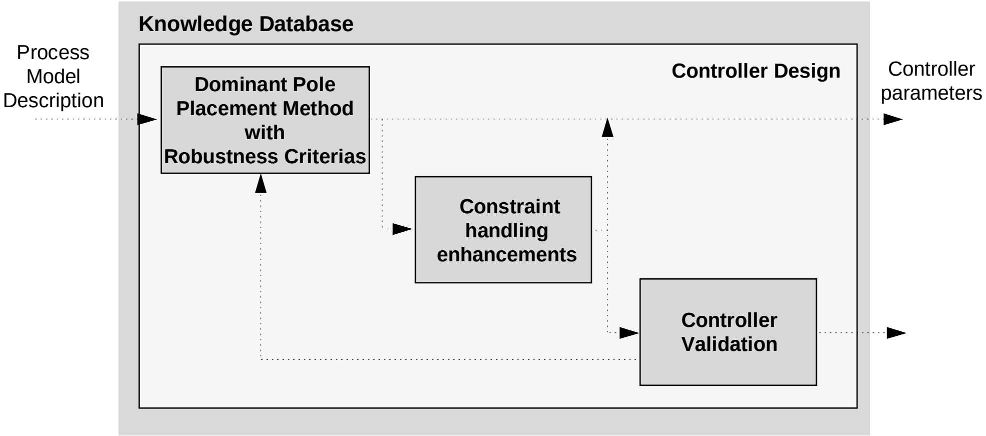

Knowledge Database
Process Model Description
Controller Design
Controller parameters
Dominant Pole Placement Method with Robustness Criterias
Constraint handling enhancements
Controller Validation

Figure 2-9. Controller Design

In this manner all built-in powerful design utilities for creating optimal tuning parameters are handled in the most efficient manner. The top of the art design technique Dominant Pole Placement Methodology with Robustness Criterias, DPPM-RC, is used so that the highest degree of robustness and plant loop stability is created also for processes with changing dynamics.

Additional specifications can be added to the controller design part, working as constraints, in the automatic optimization for maximum performance. This means that not only maximum performance but also other specifications can be used for design of the controller tuning parameters. These extensions can also be given as pure limitations or other tuning methodologies like “Lambda” tuning, plus some special enhancements along the same methodology.

2.2.5 Loop Historian

The Loop Historian is an integrated documentation part in Loop Optimizer Suite. Each individual plant loop has a separate Loop Historian file. The Loop Historian contains the result of major activities, that is, description of plant dynamics, suggested controller parameters, etc. plus comments supplied from the engineer during his work. This means that the Loop Historian normally supplies the answer for each and every question regarding the loop. Via the Loop Historian it is possible to find out why and when the current active tuning parameters were selected. It is also possible to check the raw data used for that occasion. The Loop Historian also documents the origin for each calculated result, that is, the plant loop raw data file used.

The result of a user initiated Loop Performance Assessments Batch session is automatically stored in the Loop Historian. If the Scheduler activated the Batch, the result is automatically stored in the Loop Scheduler Historian instead. The Loop Scheduler Historian is used by the Plant Auditing Report Generator.

The Loop Historian and the Loop Scheduler Historian are both editable text files that can be used by any editor for further use or easy integration into other program packages for further data propagation. Figure 2-10 shows the structure of the different files used in a LPA Batch activity

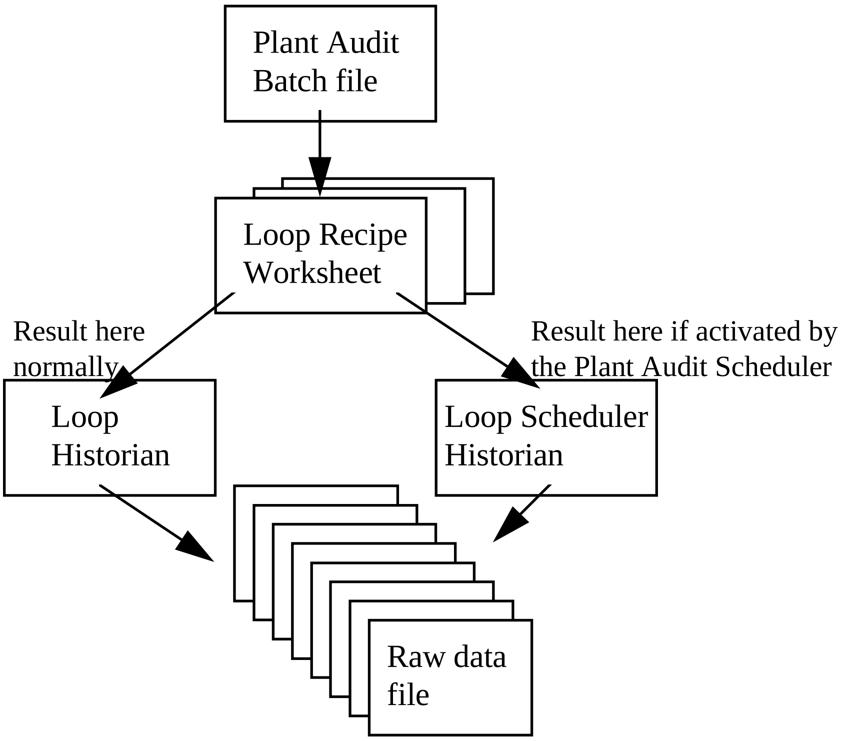


Figure 2-10. File structure in a LPA Batch activity

The condensed result of a plant auditing session is stored in the Loop Scheduler Historian so that further analysis can be based on the results. Within the Loop Scheduler Historian, the origin from were the calculated results has evolved, is also documented. This means that further higher level assessments can easily be done using the calculated results.

2.2.6 Data Acquisition

Data acquisition from the OCS/DCS instrumentation system can be done via the following protocol techniques; DDE (Dynamic Data Exchange), Excom and printer emulation. Loop Optimizer has a DDE Client integrated; data can be acquired from a majority of DDE Servers on the market, which means it is instrumentation system independent. Excom is an Advant Master serial protocol that supplies multi node data access over a network. The printer emulation makes data acquisition possible from any type of system that can write data to a RS 232 C serial port device.

Via the generic program structure new protocols can be integrated when so required.

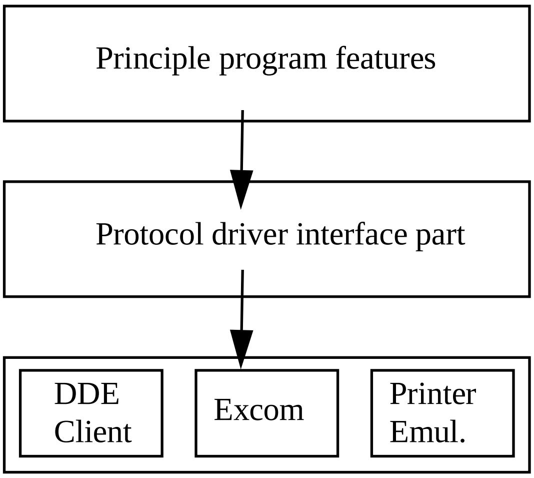


Figure 2-11. Protocol support layers

2.2.7 Statistical Process Control

The Statistical Process Control, SPC, part in Loop Optimizer supplies a large set of possibilities to further evaluate the process data acquired. Via the statistical analysis it is possible to understand if correlation can be found between problems in different parts of the plant. It also supplies supervision of the frequency spectrum in the data and how the energy content is divided in various frequency regions.

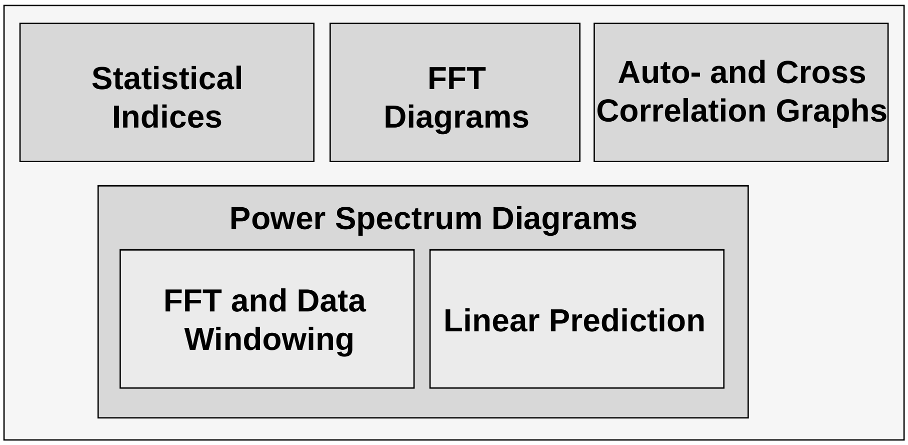
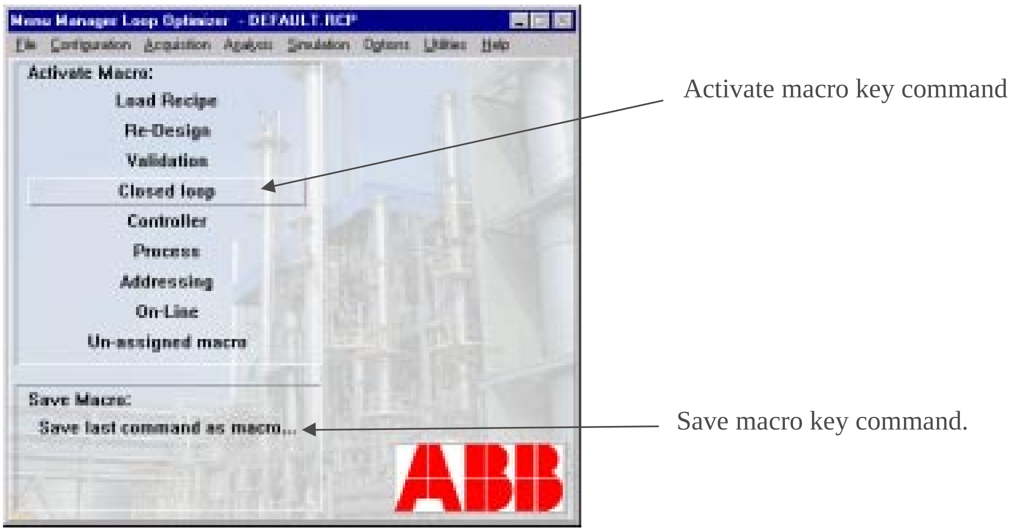


Figure 2-12. Statistical Process Control

Thereby a new perspective of the plant data can be generated that opens new possibilities for plant supervision.

2.2.8 Intelligent User Interface

Via the enhanced windows handling features, developed for Loop Optimizer Suite, the user has instant access to the advisory information for each new activity, template parameter or menu option. The advisory window is more or less the user manual integrated directly into the program assistance system. Thereby the advisory information is instantaneously available without any kind of search activity! Via the macro key handling, that is, the built-in Macro Menu Manager, complex work and program movements can be done in a very efficient manner. Repetitive work is easily and efficiently done via the user defined macro handling.


Menu Manager Loop Optimizer - DEFAULT.RCP
File Configuration Acquisition Analysis Simulation Options Utilities Help
Activate Macro:
Load Recipe
Re-Design
Validation
Closed loop
Controller
Process
Addressing
On-Line
Un-assigned macro
Save Macro:
Save last command as macro...
ABB

Activate macro key command

Save macro key command.

Figure 2-13. Intelligent User Interface, Menu Manager

There are nine macro keys and different macro key settings can be stored giving the user a possibility to have multiple sets of macro key definitions adapted for different activities. Via the enhanced macro key feature, program handling has been improved 25% compared to conventional windows handling. The Macro Menu Manager is used during the fully automatic Scheduler driven Plant Loop Auditing activity. Both the Menu and Template Manager allow long descriptional text for easy understanding and further improved program handling.

2.3 Loop Professional Trainer

The Loop Professional Trainer works as a large stand-alone loop simulator integrated in a DDE Server program. The DDE Server supplies the user with the possibility to train, very efficiently, various aspects of On-Line loop tuning.

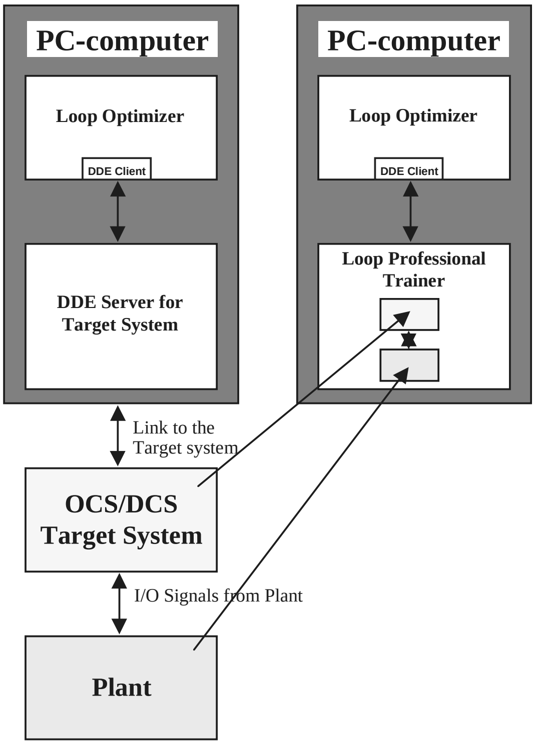
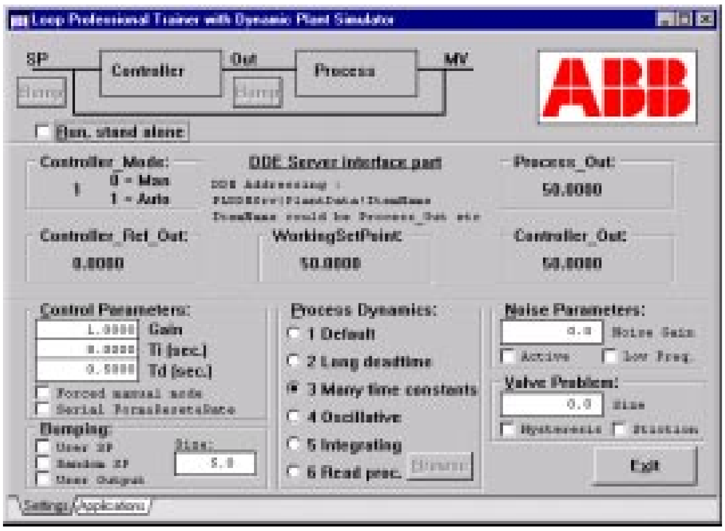


Figure 2-14. The DDE Server principle function

Via the DDE Client in the Loop Optimizer the data generated in the Loop Professional Trainer can be accessed in exactly the same way as if acquired from the OCS/DCS instrumentation system. The Loop Professional Trainer program has implemented a full plant loop were five different, pre-specified, plant dynamics can be selected. The user can also specify freely any plant loop dynamics.


Loop Professional Trainer with Dynamic Plant Simulator
SP
Controller
Out
Process
MV
Bump
Bump
ABB
DDE Server interface part
Settings
Applications
Exit

☐ Run, stand alone

Controller_Mode: 1 (0 = Man, 1 = Auto)

Process_Out: 50.0000

Controller_Ref_Out: 0.0000

WorkingSetPoint: 50.0000

Controller_Out: 50.0000

Control Parameters:
1.0000 Gain
8.0000 Ti [sec.]
0.5000 Td [sec.]
☐ Forced manual mode

Bumping:
☐ User SP
☐ Random SP
Size: 5.0

Process Dynamics:
○ 1 Default
○ 2 Long deadtime
● 3 Many time constants
○ 4 Oscillative
○ 5 Integrating
○ 6 Read proc.

Noise Parameters:
0.0 Noise Gain
☐ Active ☐ Low Freq.

Valve Problem:
0.0 Size
☐ Hysteresis ☐ Stiction

Figure 2-15. Loop Professional Trainer interface

It is possible to directly use a model identified in Loop Optimizer Suite and down-load it to the Loop Professional Trainer. A process model imported in this manner can also be extended with a loop application picture in the *.WMF format. Via the loop application picture display training can be made more realistic as site specific loops can be displayed as normally observed and understood by the plant engineers.

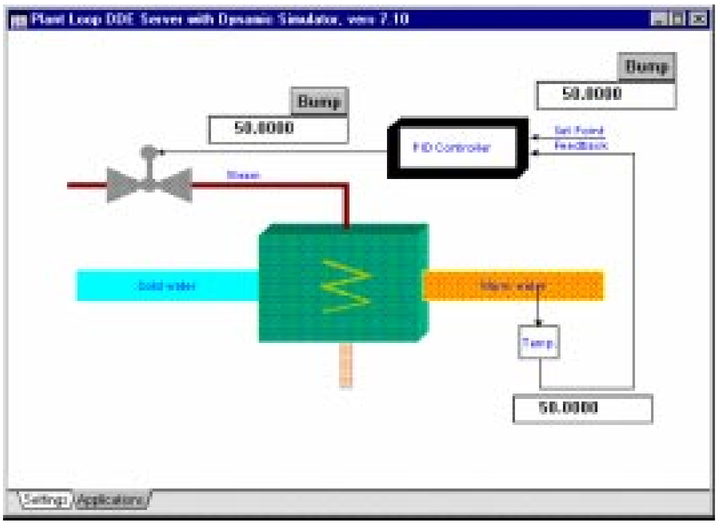


Figure 2-16. Loop Application Picture

In the Loop Professional Trainer, various types of plant problems can be included in the loop to illustrate how it will influence both performance and tuning. Typical site problems which can be activated are; hysteresis, friction, low and high frequency noise and disturbances. By using the Loop Professional Trainer the user can train, in the office, exactly how he should tackle true site problems or solve any kind of “real life” On-Line tuning activities.

Chapter 3 Requirement

The following minimum recommendations apply for the Loop Optimizer Suite program.

Personal computer (PC): Pentium II 70 MHz

Primary memory:	64 Mb
Disk space:	200MB
Operating system:	Windows NT 4.0 Service pack 4
Display unit:	17 inch monitor with 256 colors
Data access via DDE:	A DDE Server that supports the OCS/DCS system used as target system
Ports:	Parallel port for hardkey unit. If serial communication is done one serial communication port is needed too.
Devices:	One CD disk reader and one floppy disk unit for 3"1/2 disks.

Additional requirements for on-line data acquisition:

Using EXCOM for data acquisition, the EXCOM protocol must be available in the OCS system plus necessary serial communication cards. EXCOM protocol support is integrated into the Loop Optimizer Suite.

The use of DDE servers for data acquisition requires that a server is available and that it is supported. Loop Optimizer Suite has a DDE Client built-in. This means that most DDE Servers can be utilized for data acquisition.

The AdvaInform DDE Server for AF 100 and GCOM is handled via the DDE Client support part. The MOD300 DDE Server is supported via the DDE Client. Any other system from within the ABB group that has a DDE Server is supported via the built-in DDE Client, such as Satt Line, Freelance, Maestro and Symphony.

Products that uses "at a glance" protocols can be used as data can be accessed via a DDE_"at a glance" bridge software program.

Chapter 4 Ordering

The Loop Optimizer Suite program is available in four different sales packages that contain various parts of the three modules in the Loop Optimizer Suite program.

- Loop Optimizer, basic 3BSE 021 138
    - Loop Optimizer
- Loop Optimizer, standard 3BSE 021 140
    - Loop Optimizer, Loop Professional Trainer
- Loop Auditor, standard 3BSE 021 142
    - Loop Optimizer, Loop Professional Trainer, Loop Audit Scheduler and Evaluator
- Loop Auditor, professional 3BSE 021 144 (Not yet released)
    - All five program parts

Above delivery specification can be changed without prior information.

The Loop Optimizer Suite program is found in the
3BSE 007 500 Plant Optimization price book.

Marketing material is found in the Notes DB
BU Control/Marketing/Asset Optimization.

Multi-User licences are available for each of above program sales packages.

Upgrades from previous product Loop Tuner is handled via above price book.

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